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Siekmann

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[54] **FUEL PUMP ASSEMBLY**

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[51] **Int. Cl.**[5] **F02M 37/04**; E03B 11/00

[52] **U.S. Cl.** **123/509**; 123/572

[58] **Field of Search** 123/509, 514, 510, 516; 137/571, 572, 575, 576, 578

[56] **References Cited**

U.S. PATENT DOCUMENTS

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4,971,017	11/1990	Beakley	123/509
4,974,570	12/1990	Szwargulski	137/572
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[57] **ABSTRACT**

An engine fuel system includes a fuel pump located within an upright reserve fuel container located in a fuel tank. Fuel is admitted to the inlet chamber of the pump through separate poppet valves associated with the fuel tank and the reserve fuel container. The container is a sealed construction that isolates the fuel in the container from the fuel in the tank. The poppet valve leading from the tank to the pump is operated by a float that is responsive to the fuel level in the tank. At low tank fuel levels (empty or near empty), the float-operated poppet valve is closed. The two valves are interconnected by a lost motion connection such that the poppet valve associated with the reserve container is openable by pressures generated in the return fuel line, or by suction forces generated by the fuel pump. The reserve container is maintained in a filled condition ready for supplying fuel to the pump when the fuel tank is in a near empty condition.

16 Claims, 2 Drawing Sheets

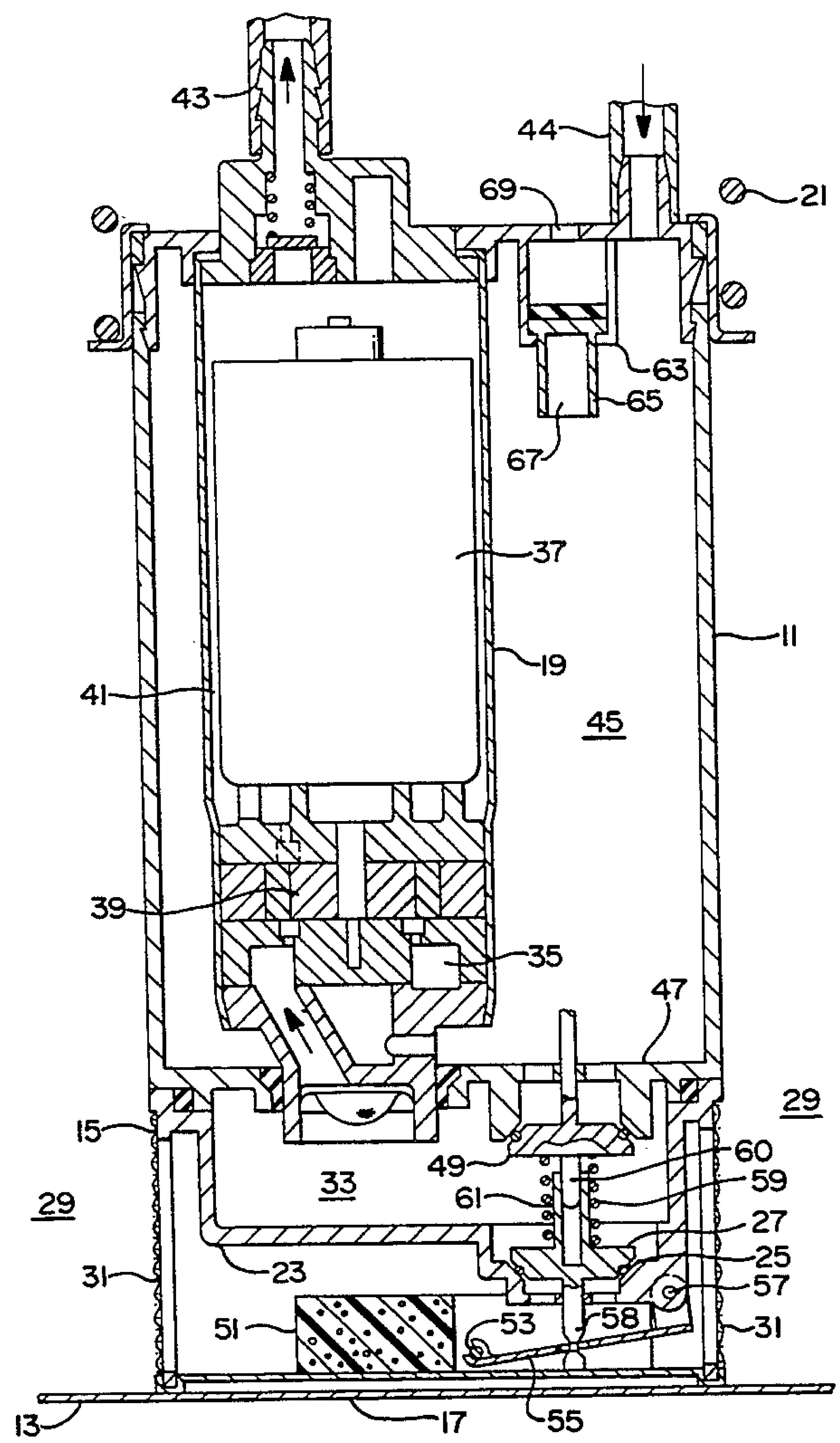

FIG 1

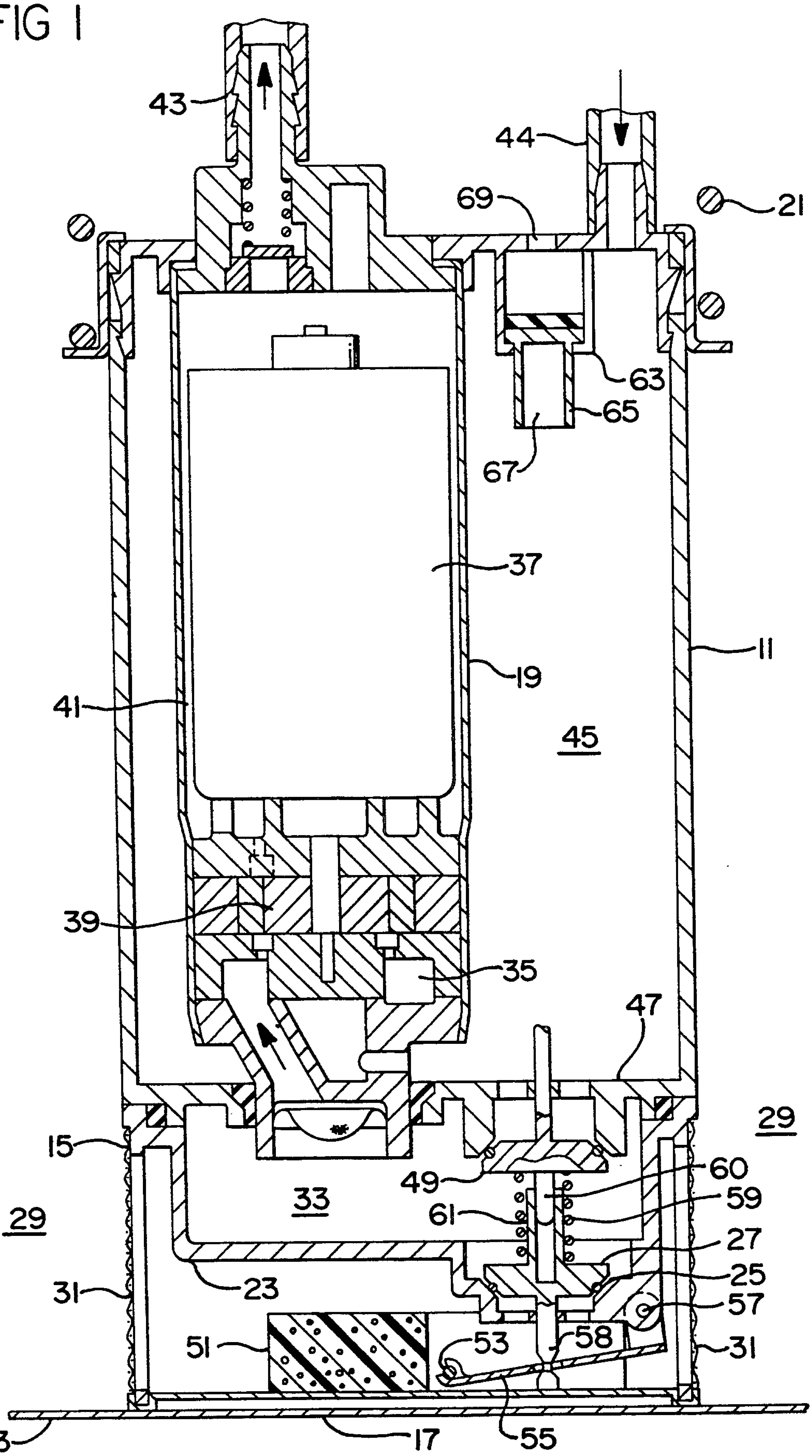
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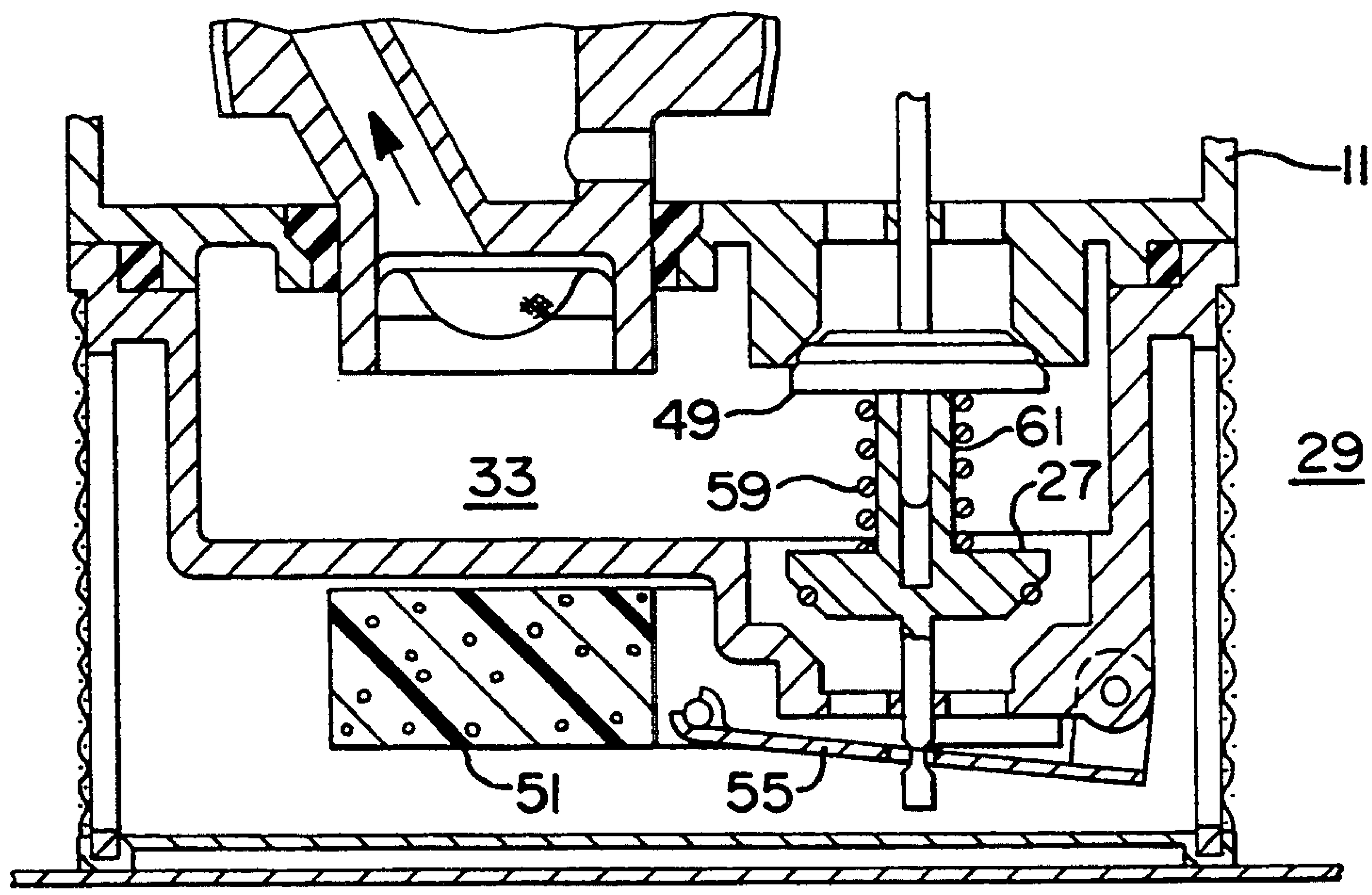
FIG 2



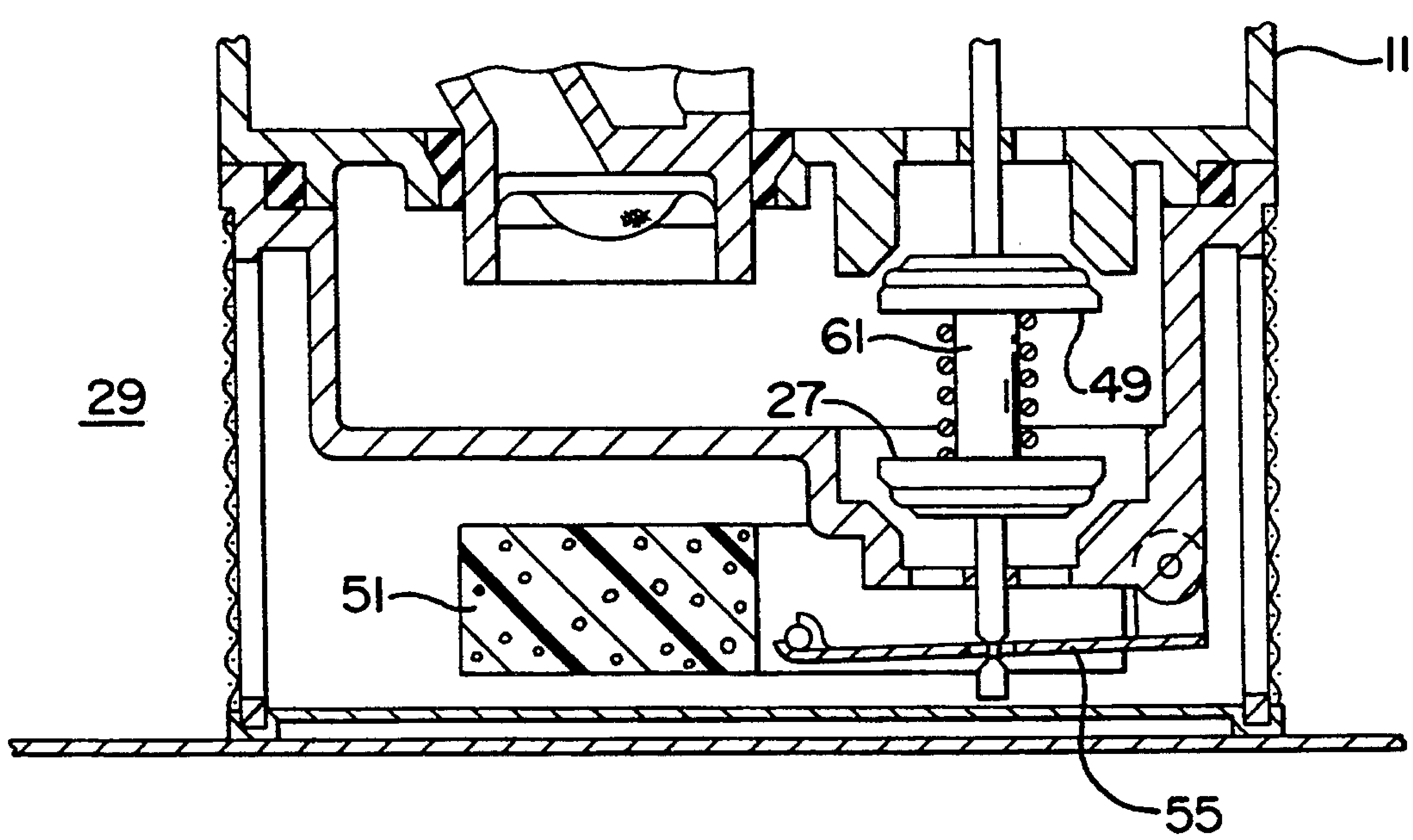


FIG 3

FUEL PUMP ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to vehicle engine fuel supply systems and, particularly, to a fuel supply system having a reserve fuel container and fuel pump located within the vehicle fuel tank.

2. Description of Prior Developments

It is known to provide a fuel container in a vehicle fuel tank for supplying fuel to a fuel pump when the tank is essentially empty, or when the fuel in the tank is sloshing or thrown away from the pump inlet chamber due to vehicle turning maneuvers.

U.S. Pat. No. 4,974,570 to Szwargulski shows a reserve fuel supply system that includes a pressure responsive valve for conveying fuel from a reserve container to the fuel pump when a float valve in the tank closes due to lack of fuel in the tank. The reserve fuel container has an open top such that fuel vapors associated with heated fuel can circulate between the reserve container and the surrounding space in the fuel tank.

Conventional engine fuel systems have fuel pumps that are sized to deliver more fuel than the engine can use. Excess fuel not used by the engine is returned to the fuel tank via a return line. The excess fuel is usually heated as a result of its travel through the engine fuel injectors or other heated passageways. Consequently, the returned fuel tends to heat the fuel in the tank.

Under some conditions, fuel vapors from the heated fuel can form in the tank to such an extent that, when the motorist opens the gas cap on the tank to add fuel, the accumulated vapors can escape into the ambient atmosphere. Such vapor escape represents an air pollution problem that the present invention is designed to reduce.

Fuel supply systems having reserve fuel containers within the fuel tanks are disclosed in various patents, e.g., U.S. Pat. Nos. 3,443,519; 4,672,937; 4,747,388; 4,776,315; 4,807,582; and 4,831,990. It is not believed that any of these patent disclosures address the problem of fuel vapor accumulation and vapor escape from the fuel tank.

SUMMARY OF THE INVENTION

The present invention is directed to an automotive engine fuel supply system that includes a reserve fuel container located within a conventional fuel tank, such that excess fuel not used by the engine is returned only to the reserve fuel container where it is isolated from the main body of fuel in the tank. A system of valves is provided so that the fuel pump normally draws its fuel supply partly from the tank and partly from the reserve container.

Part of the fuel supplied to the pump is in a heated condition due to its having come from the reserve container instead of from the fuel tank. Therefore, since the returned fuel from the engine is continually being recycled through the fuel pump, the general temperature of the fuel in the tank is kept relatively low, such that vapor generation is reduced. Also, most of the vapors that are produced are confined to the reserve container or are carried away by the fuel pump. As a result of these factors, there is a lessened potential for fuel vapor escape when the tank filler cap is opened for adding fuel to the tank.

In a preferred arrangement, the fuel tank is connected to the fuel pump via a float-operated poppet valve located below the reserve fuel container and in open communication with the pump inlet chamber. The reserve fuel container has a second poppet valve axially aligned with the first mentioned poppet valve, with both valves being adapted to feed fuel to the pump inlet chamber.

A lost motion connection is provided between the two poppet valves, whereby the valves can be selectively opened and closed depending on the condition of the float and fuel levels in the tank and reserve container. The system is designed to minimize the formation or accumulation of fuel vapors in the fuel tank from heated fuel and provides a reserve fuel supply for the fuel pump when the tank is in a near empty condition that would otherwise deprive the pump of fuel.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a sectional view taken through a reserve fuel container and control valve assembly used in an engine fuel supply system in accordance with the present invention.

FIG. **2** is a fragmentary view taken in the same direction as FIG. **1**, but showing the valve assembly in a different operational mode.

FIG. **3** is a fragmentary view taken in the same direction as FIG. **1**, but showing the valve assembly in another operational mode.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The engine fuel system shown in FIG. **1** includes an upright cylindrical fuel container **11** positioned within a fuel tank **13**. The container includes a hollow partitioned base structure **15** that seats on the bottom wall **17** of the fuel tank. The top wall of the fuel tank (not shown) has an access opening therein for the purpose of installing the fuel container into the tank.

After the container has been inserted downwardly through the access opening, a cover (not shown) is mounted over the access opening. The cover has fittings and electrical connections for fuel lines and wiring associated with a fuel pump **19** located within container **11**. A coil spring **21** can be positioned between container **11** and the cover to firmly position the container within the fuel tank. The overall installation may be similar to that depicted in U.S. Pat. No. 4,974,570.

Base structure **15** includes an internal partition **23** that forms a valve opening **25**. Seated on the valve opening is a poppet valve **27**. Fuel can flow freely from the fuel tank space **29** through a filter screen **31** into the space below poppet valve **27**. When the valve is open, as shown in FIGS. **2** and **3**, the fuel can flow upwardly through the valve opening **25** into an internal chamber **33** that is in open communication with the inlet chamber **35** of fuel pump **19**.

Fuel pump **19** may be a gear pump constructed as shown in U.S. Pat. No. 4,820,138 to Bollinger. The pump includes an electric motor **37** that drives an external gear **39**, whereby liquid fuel is pumped upwardly into an annular space **41** and through motor **37** for motor cooling and eventually into a fuel line **43** going to the engine.

The quantity of fuel delivered by the pump is greater than the quantity required by the engine. Excess or unused fuel is returned to fuel container **11** through a return line **44** where it collects in the container space **45**. All of the returned fuel goes into container **11**, effectively none goes back to the fuel tank.

A lower wall **47** of the fuel container has a valve opening or valve seat that receives a poppet valve **49**. When poppet valve **49** is open, as shown in FIG. **3**, fuel can flow downwardly from container space **45** into chamber **33**. FIG. **3** shows one condition wherein both poppet valves **27,49** are open. The fuel pump then draws fuel from the fuel tank and from container **11**.

FIG. **2** shows a second condition wherein poppet valve **49** is closed and poppet valve **27** is open. The fuel pump then draws fuel solely from the fuel tank space **29** through valve **27**. There is a third condition (not shown) wherein valve **49** is open and valve **27** is closed. The pump then draws fuel solely from container **11** through valve **49**. Valve **27** is referred to as a lower valve, and valve **49** is referred to as an upper valve. The two valves are vertically aligned on a common movement axis.

Valve **27** is opened and closed by a buoyant float member **51** that has a generally C-shaped configuration in top plan view. A horizontal pivot pin **53** extends through the float member **51** and across the space within the C-shaped float member for connection with a lever arm **55**. The lever arm is swingable in a vertical arc around a fixed pivot axis **57**, whereby the float member **51** is enabled to move vertically up or down depending partly on the quantity of fuel in tank **13** and the degree to which the fuel might be sloshing back and forth in the tank. Pivot pin **53** enables float member **51** to maintain a level attitude throughout its vertical stroke.

FIG. **1** shows float member **51** in a lowered position produced by an empty tank or by a tank fuel level less than the predetermined value required for normal operation of the fuel pump. FIG. **2** shows float member **51** in a raised position produced by higher than minimum fuel levels in the tank. FIGS. **1** and **2** represent the limits of the float member stroke.

Poppet valve **27** has a stem **58** that has a pivot connection with lever arm **55**. A neck portion of the stem extends within a slot in arm **55**, whereby arcuate motion of the arm translates into vertical motion of the poppet valve.

The two poppet valves **27** and **49** are interconnected by a lost motion connection that includes a coil spring **59** and a hollow sleeve-like rod **61**. As shown, hollow rod or tube **61** extends upwardly from poppet valve **27** for slidable motion on a pin **60** that extends downwardly from poppet valve **49**, whereby the two poppet valves have relatively good axial and radial alignments with the associated valve seats. The length of rod **61** is less than the spacing between valves **27** and **49** when the valves are in their closed positions as shown in FIG. **1**.

Coil spring **59** exerts an upward biasing force on poppet valve **49** and a downward biasing force on poppet valve **27**. The force of spring **59** is less than the upward buoyant force developed by float member **51** such that the float member is enabled to lift poppet valve **27** to an open condition, as shown in FIG. **2**.

Referring to FIG. **1**, container **11** has a cage structure **63** depending from its upper wall **64** for slidably supporting a closure means such as float valve **65**. Valve **65** has a cup shape that forms an air chamber **67** when the fuel level rises in container space **45** to a point where it reaches the lower edge of the cup. A rising fuel level in container space **45** lifts valve **65** so that it seals a vent opening **69** in container wall **64**. When the fuel level in the container is lowered, the float valve **65** returns to the open position as shown.

Float valve **65** could also take the form of a dynamic flow valve which remains open for vapor flow when container space **45** is filling, but closes when liquid tries to flow past it.

The spring force of spring **59** is sufficient to support the head of liquid in container **11** until the container is completely filled, i.e. until vent opening **69** is closed by valve closure means **65**. However, when vent opening **69** is closed, continued flow of fuel through return line **44** toward container **11** produces a pressure in line **44** that slightly pressurizes the container space **45**. Such pressure is sufficient to open the upper poppet valve **49** for feeding the pump **19** with fuel from container **11** as depicted in FIG. **3**.

The above discussion on the force of spring **59**, and the action of poppet valve **49**, is somewhat simplified in that it does not take into account the suction force produced by the fuel pump, i.e. the suction condition existing in chamber **33**. Under some conditions, valve **49** will be open even when container space **45** is at atmospheric pressure.

Referring to the general operation of the illustrated system, FIG. **1** represents the condition of an empty fuel tank with essentially no fuel in tank space **29** or container space **45**. As new fuel is added to the tank, float member **51** will be lifted to the FIG. **2** position wherein poppet valve **49** is opened by the buoyant force of the float member. Hollow rod **61** is of such a length that poppet valve **27** can move up to the open position without disturbing valve **49**. If sufficient fuel is added to the tank, some of the fuel may enter container **11** through the vent opening **69**. The addition of fuel into container **11** is, however, not necessary for operation of fuel pump **19**. The pump can draw fuel from tank space **29** through the open poppet valve **27**.

FIG. **2** represents the operating condition when there is an adequate supply of fuel in tank space **29** and less than a complete filling of container **11**. During normal operation of the fuel pump, excess or unused fuel returns from the engine through return line **44** such that, after a period of operation, container **11** is completely filled. Float valve **65** then seals vent opening **69** such that continued return of fuel slightly pressurizes the fuel in container space **45**.

FIG. **3** represents the condition of poppet valves **27** and **49** during normal operation of the fuel pump with container space **45** slightly pressurized. The force of the liquid fuel on the upper face of poppet valve **49** causes valve **49** to open such that the valve assembly moves slightly downwardly to the FIG. **3** condition. The fuel pump is then drawing fuel from the tank through valve **27** and also from container **11** through valve **49**. The valve assembly may reciprocate slightly depending on fuel demand by the engine.

As the fuel level in tank **13** gradually lowers due to consumption of fuel by the engine, there comes a time when the tank fuel level falls below the level required to keep float member **51** in a buoyant condition. Due to fuel sloshing back and forth in the tank or due to the absence of fuel in the tank, the float member will gravitate to the FIG. **1** condition, wherein valve **27** is closed. However, the upper poppet valve **49** will remain in the open condition until container **11** is essentially emptied of fuel.

With valve **27** closed and container **11** having a reserve fuel supply in space **45**, the pump suction force in chamber **33** has an increased effect on valve **49**. Also, float member **51** exerts no buoyant force on the poppet valve assembly because the float member is deprived of the fuel that produces the buoyant condition. The float member **51** will exert a downward force on valve **27**, thereby allowing the pump to pull fuel through valve **49** when no fuel is around float member **51**. Pump suction force in chamber **33**, together with the liquid head in container **11** and downward force exerted on valve **27** by float member **51**, overcomes the force of spring **59** whereby valve **49** is open until and after container **11** is in an essentially empty condition.

The illustrated fuel supply system achieves several purposes. During normal pump operation, reserve container **11** is maintained in a filled condition and is thus able to supply reserve fuel to the pump when the tank is in a near empty condition or when fuel is sloshing back and forth in the tank.

During normal operations (FIG. **3**), the pump is drawing an appreciable portion of its fuel supply from container **11** through valve **49**. The fuel returning from the engine is somewhat hotter than the fuel in tank space **29**. Vapor pressure increases are confined to the fuel in container **11** so that the fuel in tank space **29** is relatively cool and vapor-free. There is thus a lessened potential for fuel vapors to escape from the tank into the atmosphere when the motorist opens the gas tank cap to refill the tank.

The valve assembly of the present invention has, as a principal objective, the minimization of fuel vapor emission from the fuel tank into the atmosphere through the opened gas tank cap. This objective is achieved without sacrificing the feature of having a reserve fuel supply that prevents pump inoperability due to an insufficient fuel supply.

What is claimed is:

1. A fuel supply system for an engine, comprising:
- a fuel container positionable in a fuel tank;
- a fuel pump for supplying fuel to an engine, the fuel pump having an inlet chamber selectively communicating with the fuel tank and the fuel container;
- a return line connected to the fuel container for returning unused fuel to the fuel container;
- an upper valve for controlling fuel flow from the fuel container to the pump inlet chamber;
- a lower valve for controlling fuel flow from the fuel tank to the pump inlet chamber:
- float means for opening the lower valve when the fuel level in the tank is above a predetermined minimum value; and
- lost motion means interconnecting the lower valve and the upper valve.

2. The fuel supply system of claim **1**, wherein the lost motion means comprises a spring biasing the upper valve to a closed position.

3. The fuel supply system of claim **1**, wherein the lost motion means comprises a spring trained between the lower valve and the upper valve.

4. The fuel supply system of claim i, wherein the lost motion means comprises a coil spring trained between the lower valve and the upper valve, so that the spring exerts an upward biasing action on the upper valve and a downward biasing action on the lower valve.

5. The fuel supply system of claim **4**, wherein each said valve is a poppet valve.

6. The fuel supply system of claim **1**, wherein the lost motion means comprises an elongated rod means extending axially from one of the valves toward the other valve, the rod means having a lesser length than the spacing between the valves when the valves are closed.

7. The fuel supply system of claim **6**, wherein the lost motion means comprises a coil spring trained between the lower valve and the upper valve, whereby the spring exerts an upward biasing action on the upper valve and a downward biasing action on the lower valve.

8. The fuel system of claim **7**, wherein the coil spring encircles the rod means.

9. The fuel system of claim **1**, wherein the upper valve is a poppet valve having a lower face exposed to pump inlet chamber suction forces, whereby the upper valve is drawn downwardly to an open position when the float means is in a nonbuoyant condition resulting from a tank fuel level less than the predetermined minimum value.

10. The fuel supply system of claim **1**, wherein the fuel pump is located within the container.

11. The fuel supply system of claim **1**, wherein the upright container has a vent opening communicating with the fuel tank and means for automatically closing the vent opening when the container is substantially filled with fuel, whereby fuel vapors are then trapped within the container.

12. The fuel supply system of claim **1**, wherein the float means comprises a lever arm swingable in a vertical arc around a fixed pivot axis and a buoyant float member having a pivotal connection with the lever arm; the lower valve being connected to the lever arm so that vertical motion of the float member produces a vertical movement of the lower valve.

13. The fuel supply system of claim I, wherein the lost motion means comprises a coil spring trained between the lower valve and the upper valve; the spring developing a lesser force than the buoyant force developed by the float means.

14. A fuel supply system for an engine, comprising:
- a fuel container positionable in a fuel tank;
- an excess fuel line connected to said container for returning unused fuel to said container;
- a fuel pump for supplying fuel to an engine, said fuel pump having an inlet chamber communicating with said fuel tank and said container;
- a first valve for controlling fuel flow from said container to said pump inlet chamber;
- a second valve for controlling fuel flow from said tank to said pump inlet chamber; and
- means for operating said valves so that, when the fuel level in said tank is below a predetermined minimum value, said second valve is closed and said first valve is open; and, when the tank fuel level is above said predetermined minimum value and said container is filled with fuel, both valves are open whereby said pump inlet chamber then receives fuel from both said tank and said container.

15. The supply system of claim **14**, wherein said operating means comprises a float means connected with said second valve and a spring trained between said first valve and said second valve.

16. The fuel supply system of claim **15**, wherein said spring is a coil spring coaxial with said first and second valves.

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